Interagency Performance Evaluation Team (IPET)

Measure of Flood Damages to Structures, Contents, and Vehicles Associated with Hurricane Katrina in 5-Parish New Orleans Metro Area

Keven Lovetro
Brian Maestri

Analysis Performed Using Custom GIS-Application

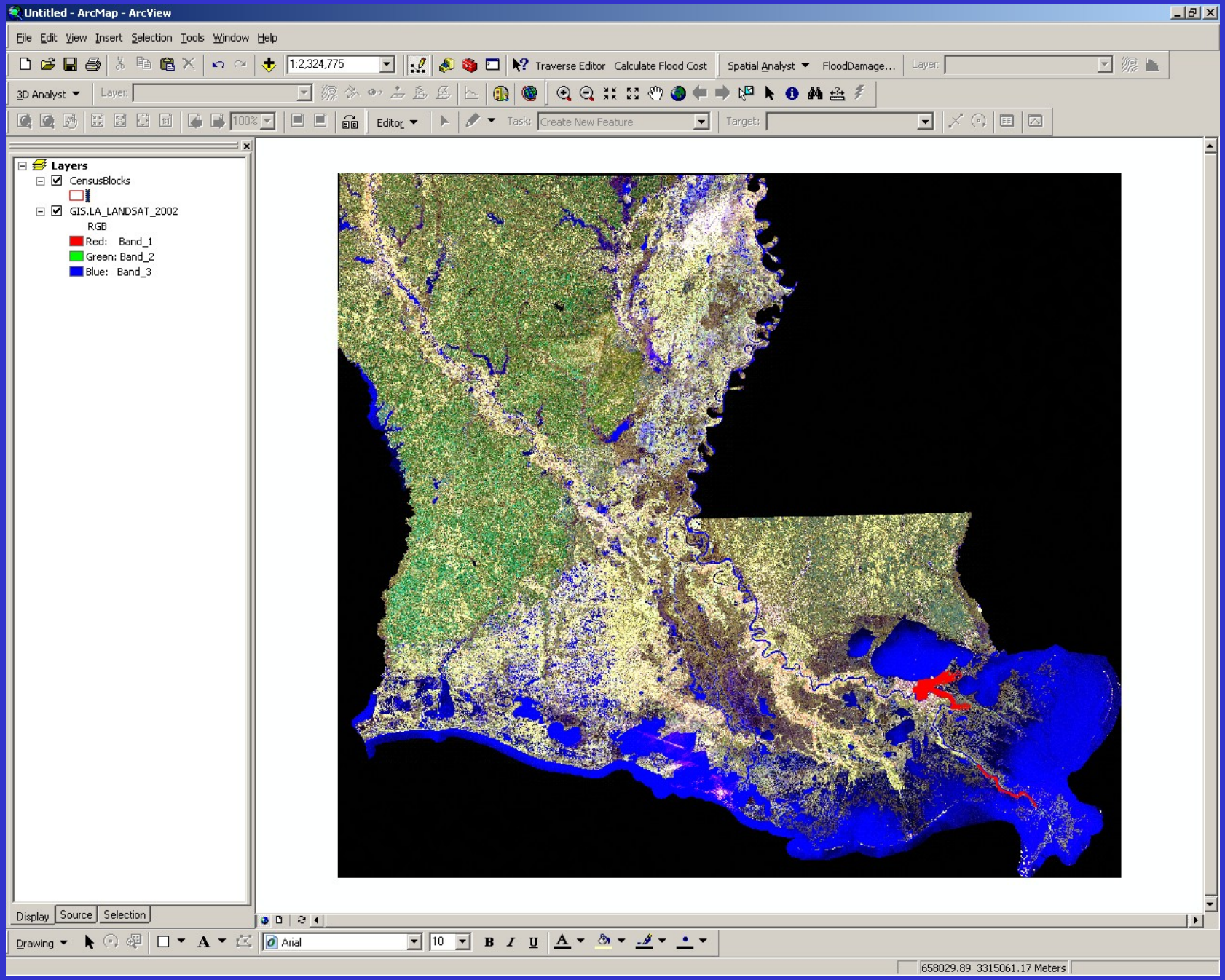
- Elevation Layers
  - LIDAR Digital Elevation Model (DEM)
    - Mean ground elevation (by census block)
  - First Floor Elevation Surveys
    - Average height above ground (by census block)
      - Pier foundation

Hydraulic Layers

- Flood Depth Grids for Portions of Parishes Where Levees and Floodwalls were Overtopped or Breached
  - Orleans
  - Jefferson
  - St. Bernard
  - Plaquemines

Four Flood Depth Grids

- Central New Orleans – Gentilly, Lakeview, Mid-City, Uptown (Broadmoor), and Old Metairie
- New Orleans East
- Lower 9th Ward and St. Bernard Parish
- Plaquemines Parish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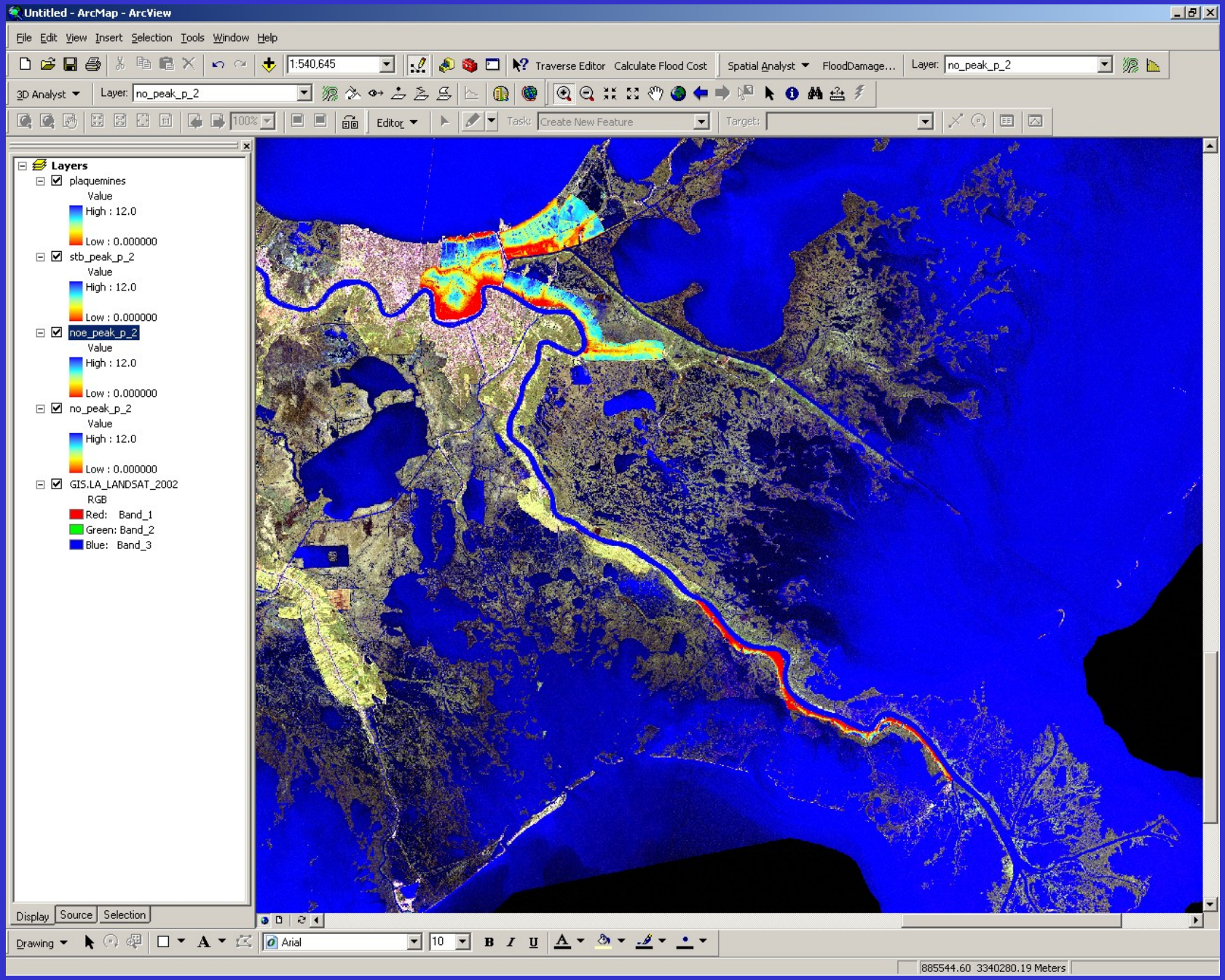
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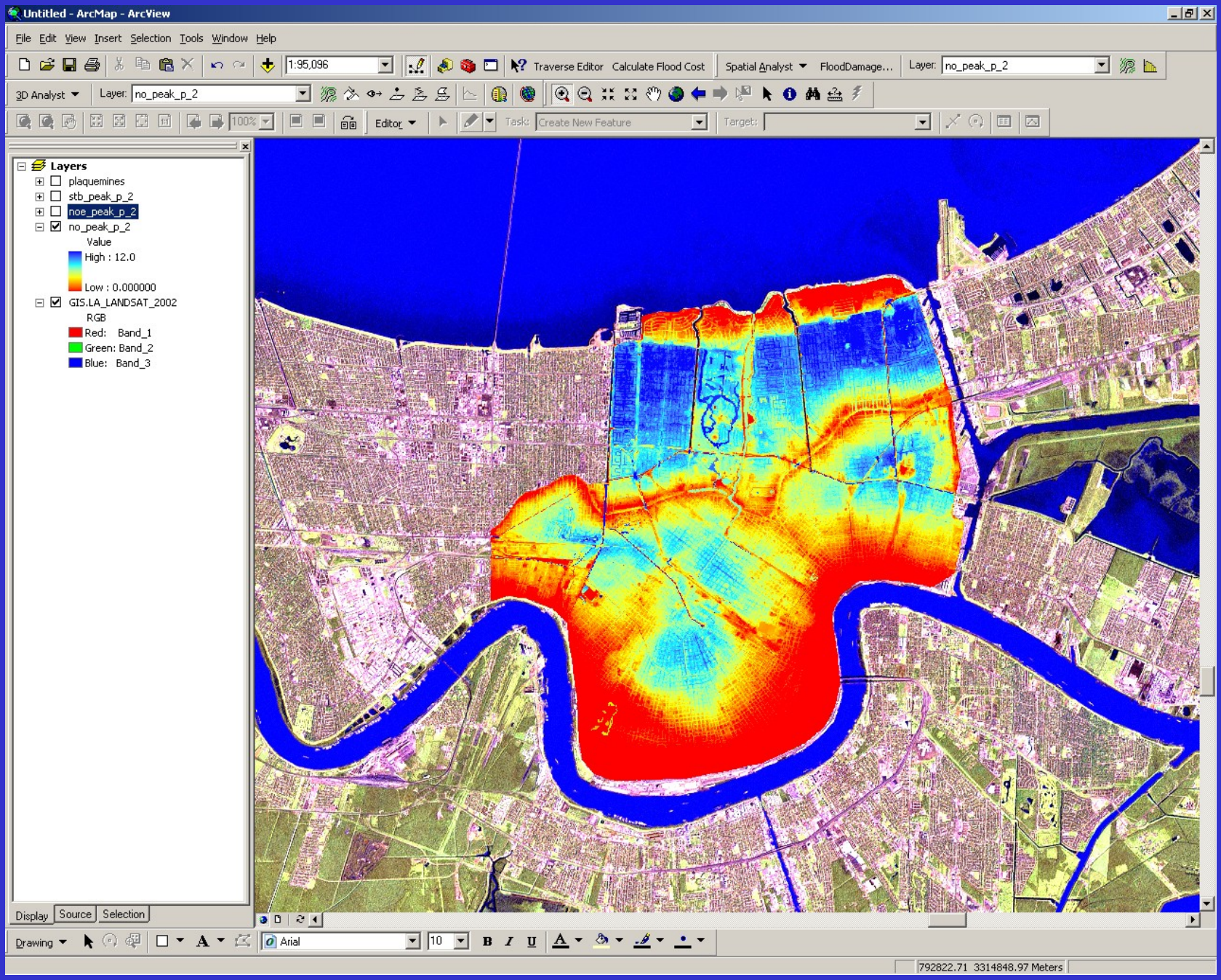
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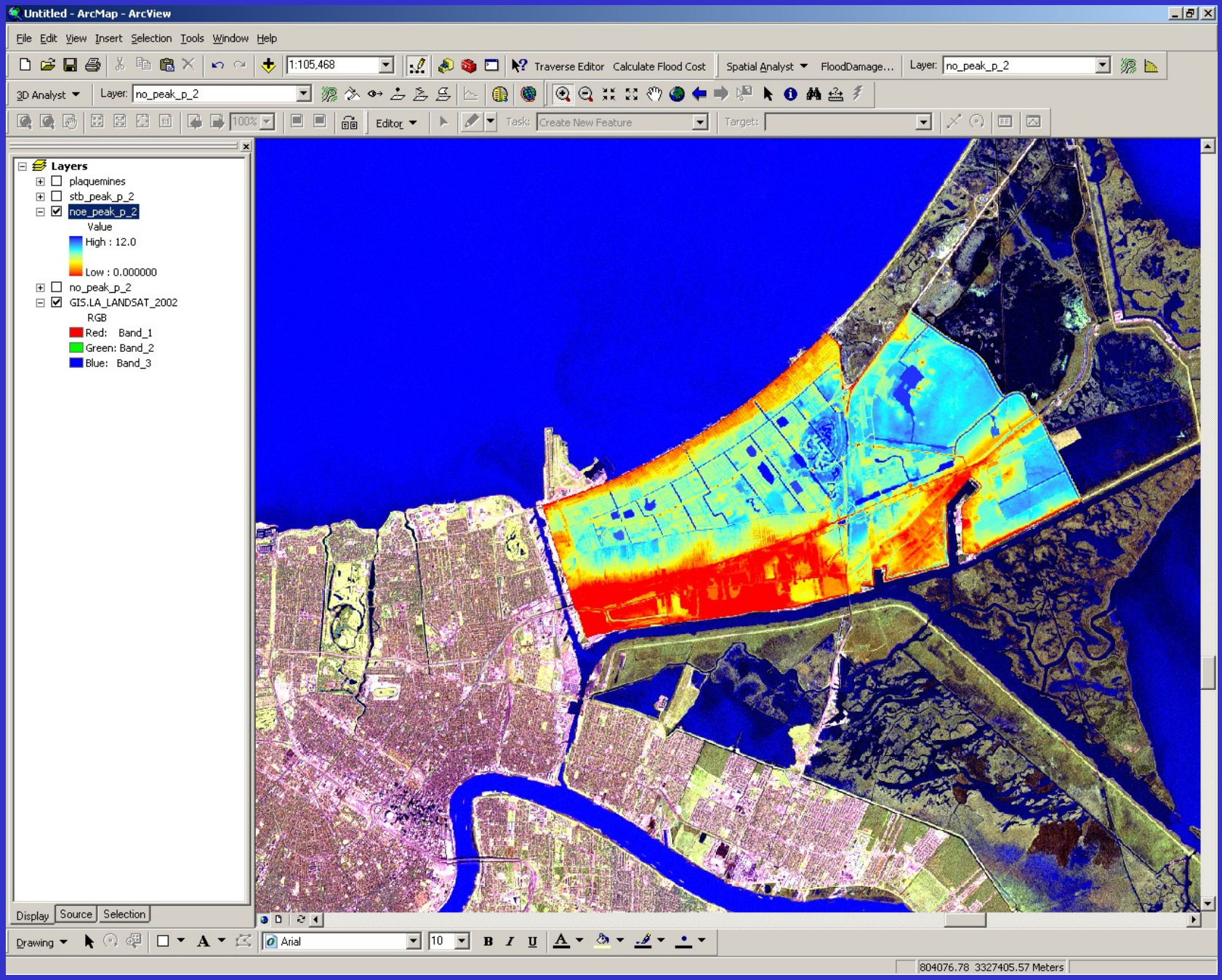
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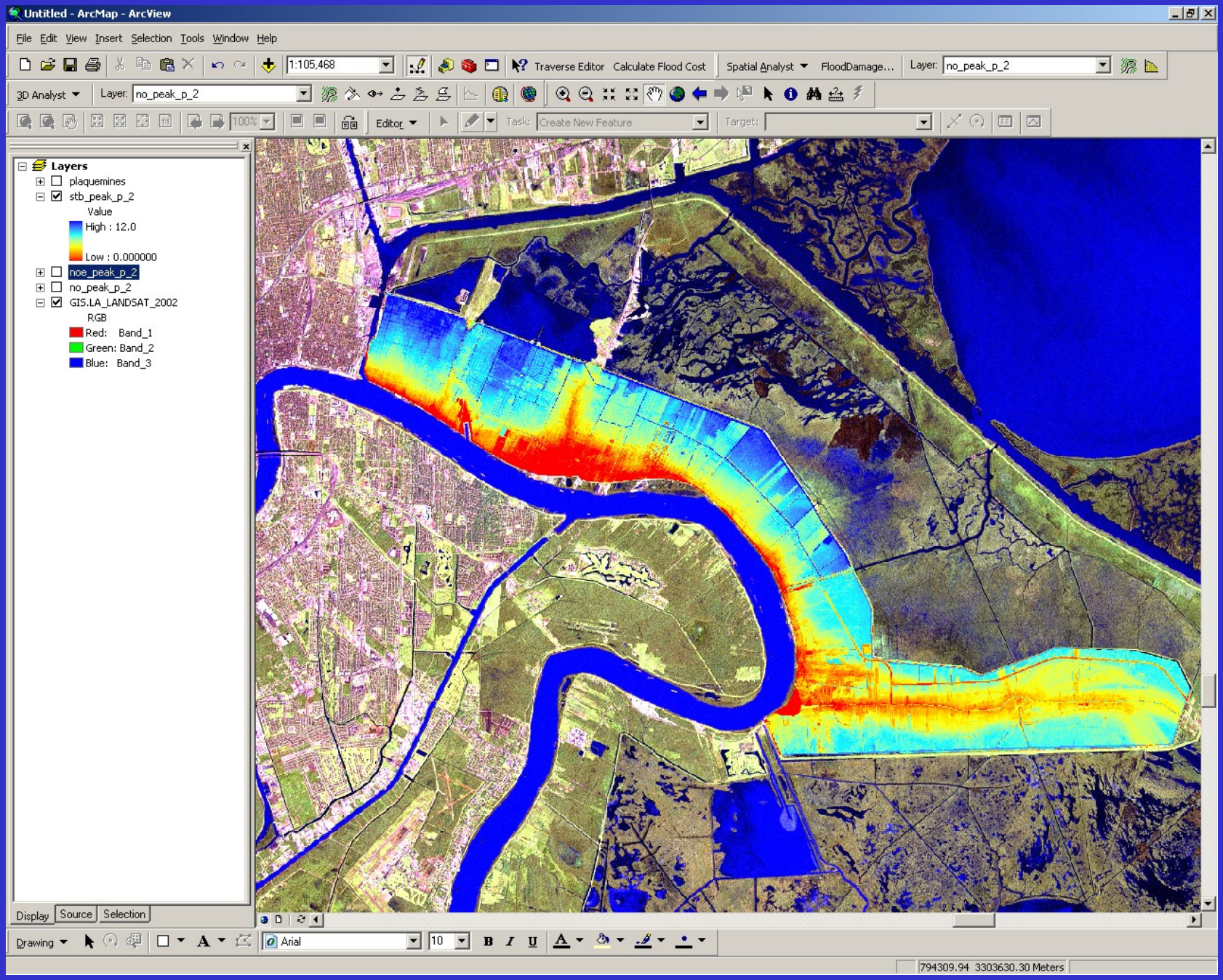
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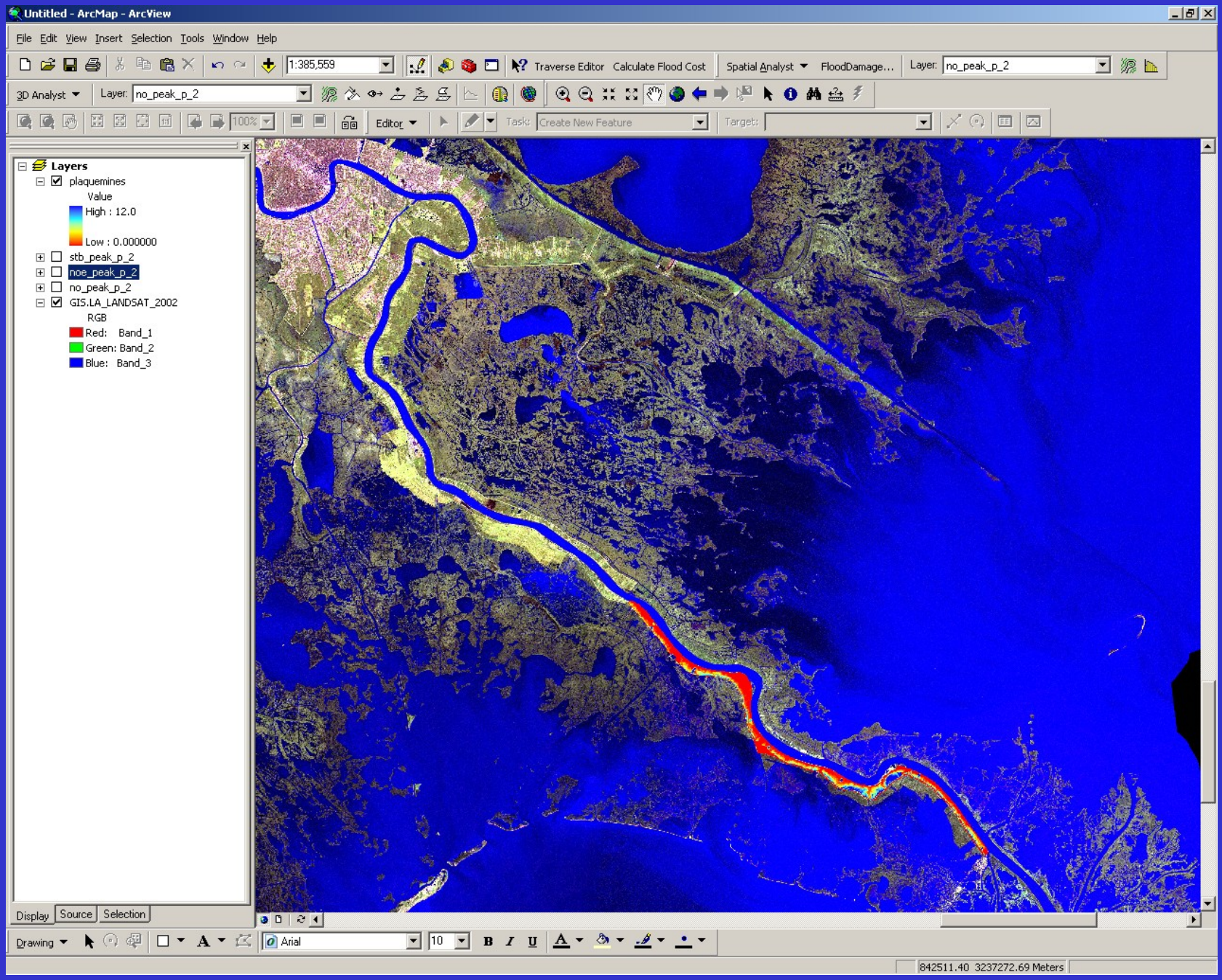
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Preliminary Property Damage Estimate for Flood Depth Grids
(in billions)

Residential:	$11.0
Commercial:	2.1
Vehicles:	4.4
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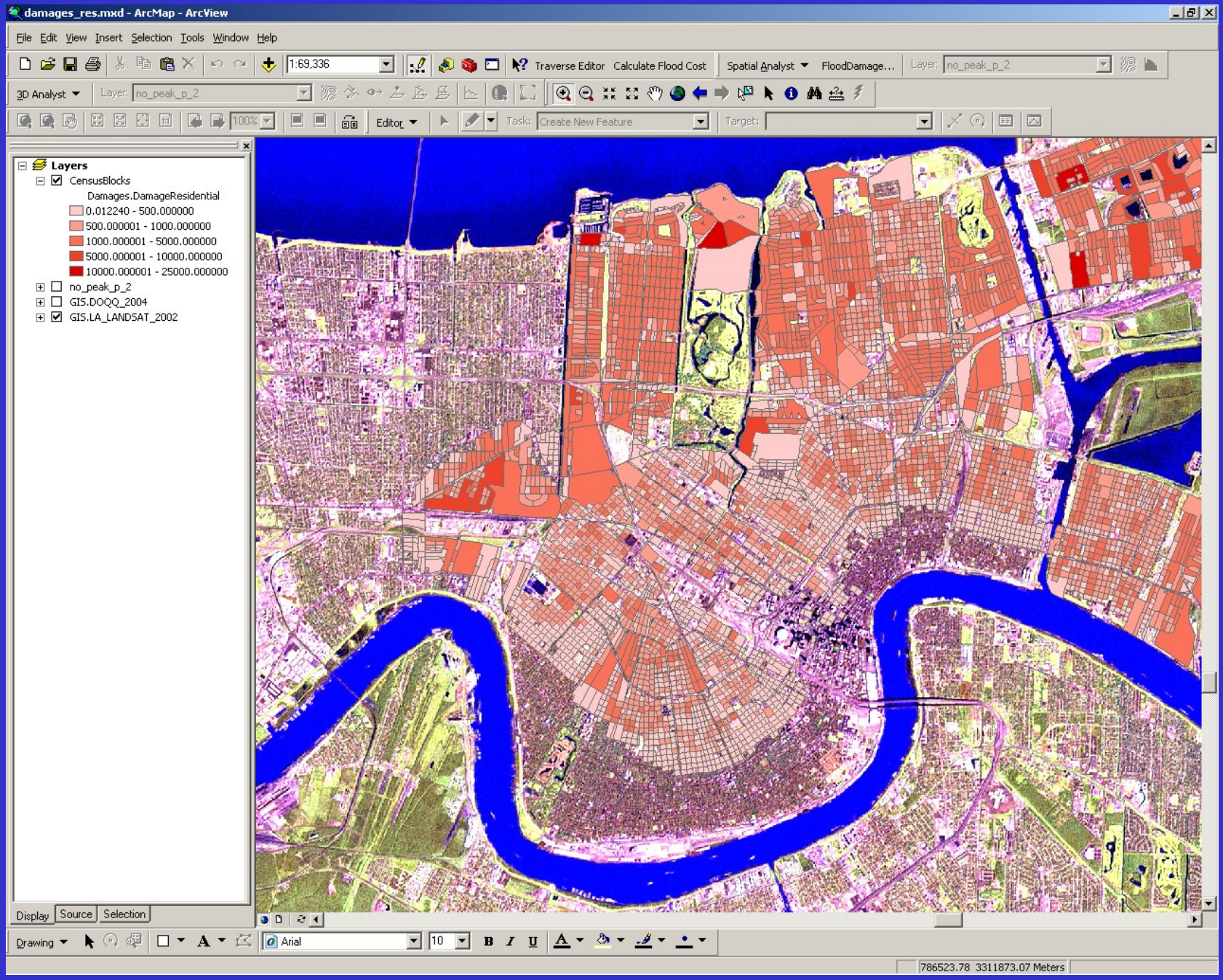
Total	$17.5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Analysis Performed Using Custom GIS-Application cont'd

- Economic Layers
  - Structure Inventory and Valuation
    - General Building Stock (HAZUS-MH Flood Model)
      - Defined by census block
      - Square footage
      - Building count
      - Depreciated exposure value

Table 1

IPET Tasks 9-10
HAZUS-MH Occupancy Categories, Stage-Damage Categories and Price Level Index

	HAZUS-MH Occupancy	HAZUS Definition	Occupancy Example	Stage-Damage Category	Marshall & Swift Index 2002-2005
1	RES1	Single Family Dwelling	1-Sty/2-Sty/Slab/Pier	SINGLE FAMILY	1.185
2	RES2	Manufactured Housing/Mobile	Manufactured Housing	MOBILE/MFG	1.185
3	RES3A	Multi Family Dwelling - small	Duplex	MULTI-FAMILY	1.164
4	RES3B	Multi Family Dwelling - small	Triplex/Quads	MULTI-FAMILY	1.164
5	RES3C	Multi Family Dwelling - medium	5-9 units	MULTI-FAMILY	1.164
6	RES3D	Multi Family Dwelling - medium	10-19 units	MULTI-FAMILY	1.164
7	RES3E	Multi Family Dwelling - large	20-49 units	MULTI-FAMILY	1.164
8	RES3F	Multi Family Dwelling - large	50+units	MULTI-FAMILY	1.164
9	RES4	Temp. Lodging	Hotel, medium	MULTI-FAMILY	1.164
10	RES5	Institutional Dormitory	Dorm, medium	MULTI-FAMILY	1.164
11	RES6	Nursing Home	Nursing home	MULTI-FAMILY	1.164
12	COM1	Retail Trade	Dept Store, 1st	COMMERCIAL	1.162
13	COM2	Wholesale Trade	Warehouse, medium	COMMERCIAL	1.162
14	COM3	Personal and Repair Services	Garage, Repair	COMMERCIAL	1.162
15	COM4	Professional/Technical/Business	Office, Medium	COMMERCIAL	1.162
16	COM5	Banks	Bank	COMMERCIAL	1.162
17	COM6	Hospital	Hospital, Medium	COMMERCIAL	1.162
18	COM7	Medical Office/Clinic	Med. Office, medium	COMMERCIAL	1.162
19	COM8	Entertainment & Recreation	Restaurant	COMMERCIAL	1.162
20	COM9	Theaters	Movie Theatre	COMMERCIAL	1.162
21	COM10	Parking	Parking garage	COMMERCIAL	1.162
22	IND1	Heavy	Factory, small	INDUSTRIAL	1.17
23	IND2	Light	Warehouse, medium	INDUSTRIAL	1.17
24	IND3	Food/Drugs/Chemicals	College Laboratory	INDUSTRIAL	1.17
25	IND4	Metals/Minerals Processing	College Laboratory	INDUSTRIAL	1.17
26	IND5	High Technology	College Laboratory	INDUSTRIAL	1.17
27	IND6	Construction	Warehouse, medium	INDUSTRIAL	1.17
28	REL1	Church	Church	PUBLIC	1.171
29	AGR1	Agriculture	Warehouse, medium	AGRICULTURAL	1.162
30	GOV1	General Services	Town Hall, small	PUBLIC	1.171
31	GOV2	Emergency Response	Police Station, Fire	PUBLIC	1.171
32	EDU1	Schools/Libraries	High School	PUBLIC	1.171
33	EDU2	Colleges/Universities	College Classroom	PUBLIC	1.171
34	n/a	n/a	Automobiles	VEHICLE	n/a

Notes:
1. Residential Single Family Dwellings (RES1) include one and story structures and slab and pier structures.
2. Private autos were estimated external to HAZUS-MH Program and valued using 2005 prices.

Residential and Non-Residential Contents Valuation

- Contents-to-Structure Value Ratios (CSVRs)
- Detail surveys of residential and non-residential structures
- Jefferson/Orleans Flood Control Feasibility Studies (June 1996)

Residential CSVRs:

- One-story 69%
- Two-story 59%
- Mobile home 79%
- Multi-family residence 37%

Non-Residential CSVRs:

- Eating and Recreation 114%
- Grocery and Gas Station 127%
- Professional building 43%
- Public and Semi-public Building 114%
- Repairs and Home Use 206%
- Retail and Personal Services 142%
- Warehouse and Contractor Services 168%

Vehicles

- 82% of households have access to at least 1 vehicle
- Vehicle accessibility per census block group ranges from 10% to 100%
- Assume one vehicle is left at residence for households with access to vehicle(s)
- Average value of privately owned vehicle is $11,819 based on Manheim Used Vehicle Index

Depth-Damage Relationships

- Jefferson/Orleans Feasibility Studies
- Developed by Panel of Building and Insurance Experts
- Saltwater/Long Duration Flooding
- Residential and Non-Residential
- Structures, Contents, and Vehicles

HAZUS-MH Occupancy Categories and Depth-Damage Relationships

	Occupancy	HAZUS Definition	Occupancy Example	Structures Depth-Damage	Contents Depth-Damage
1	RES1	Single Family Dwelling	Refer to hzRES1ReplCost	RES	RES
2	RES2	Manufactured Housing/Mobile	Manufactured Housing	MOB	MOB
3	RES3A	Multi Family Dwelling - small	Duplex	RES	RES
4	RES3B	Multi Family Dwelling - small	Triplex/Quads	RES	RES
5	RES3C	Multi Family Dwelling - medium	5-9 units	WOOD	MULTI
6	RES3D	Multi Family Dwelling - medium	10-19 units	WOOD	MULTI
7	RES3E	Multi Family Dwelling - large	20-49 units	MAS	MULTI
8	RES3F	Multi Family Dwelling - large	50+ units	MAS	MULTI
9	RES4	Temp. Lodging	Hotel, medium	MAS	MULTI
10	RES5	Institutional Dormitory	Dorm, medium	MAS	PUB
11	RES6	Nursing Home	Nursing home	MAS	PUB
12	COM1	Retail Trade	Dept Store, 1st	MAS	RET
13	COM2	Wholesale Trade	Warehouse, medium	MAS	RET
14	COM3	Personal and Repair Services	Garage, Repair	WOOD	REP
15	COM4	Professional/Technical/Business	Office, Medium	MAS	PROF
16	COM5	Banks	Bank	MAS	PROF
17	COM6	Hospital	Hospital, Medium	MAS	PROF
18	COM7	Medical Office/Clinic	Med. Office, medium	MAS	PROF
19	COM8	Entertainment & Recreation	Restaurant	WOOD	EAT
20	COM9	Theaters	Movie Theatre	WOOD	EAT
21	COM10	Parking	Parking garage	MET	PUB
22	IND1	Heavy	Factory, small	MET	WAR
23	IND2	Light	Warehouse, medium	WOOD	WAR
24	IND3	Food/Drugs/Chemicals	College Laboratory	WOOD	WAR
25	IND4	Metals/Minerals Processing	College Laboratory	WOOD	WAR
26	IND5	High Technology	College Laboratory	MET	WAR
27	IND6	Construction	Warehouse, medium	WOOD	WAR
28	REL1	Church	Church	MAS	PUB
29	AGR1	Agriculture	Warehouse, medium	MAS	WAR
30	GOV1	General Services	Town Hall, small	MAS	PUB
31	GOV2	Emergency Response	Police Station, Fire	MET	PUB
32	EDU1	Schools/Libraries	High School	MAS	PUB
33	EDU2	Colleges/Universities	College Classroom	MAS	PUB

Table 2

IPET Tasks 9 - 10

Saltwater Depth-Damage Relationships for Residential Structures, Percent Damage, Expert Panel (1-Week Damages)

	Percent Damaged				
Flood Depth (ft)	**One-Story on Pier**	**One-Story on Slab**	**Two-Story on Pier**	**Two-Story on Slab**	**Mobile Home**
-1.0	4.0	0.0	4	0.0	12.1
-0.5	5.4	0.0	4.7	0.0	12.1
0.0	20.5	7.2	17.5	5.1	32.1
0.5	62.4	56.4	53.6	44.2	62.1
1.0	62.4	56.4	53.6	44.2	63.8
1.5	64.0	58.7	54.4	45.1	64.2
2.0	65.6	58.7	55.2	46.0	66.3
3.0	65.6	58.7	55.2	49.7	66.3
4.0	68.7	63.4	56.8	51.6	66.3
5.0	71.9	66.4	59.9	51.6	66.3
6.0	71.9	66.4	59.9	51.6	66.3
7.0	71.9	66.4	59.9	51.6	66.3
8.0	71.9	66.4	59.9	51.6	66.3
9.0	84.4	82.1	63.1	55.7	66.3
10.0	84.4	82.1	71.2	66.2	66.3
11.0	84.4	82.1	72.8	68.0	66.3
12.0	84.4	82.1	74.4	68.0	66.3
13.0	84.4	82.1	74.4	69.9	66.3
14.0	84.4	82.1	74.4	69.9	66.3
15.0	84.4	82.1	74.4	69.9	66.3

Source: Expert Panel Meeting, New Orleans District USACE, March 13, 1996.

Table 3

IPET Tasks 9 - 10

Saltwater Depth-Damage Relationships for Residential Contents, Percent

	Percent Damaged		
Flood Depth (ft)	**1-Story**	**2-Story**	**Mobile Home**
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.5	95.0	95.0	95.0
1.0	95.0	95.0	95.0
1.5	95.0	95.0	95.0
2.0	95.0	95.0	95.0
3.0	95.0	95.0	95.0
4.0	95.0	95.0	95.0
5.0	95.0	95.0	95.0
6.0	95.0	95.0	95.0
7.0	95.0	95.0	95.0
8.0	95.0	95.0	95.0
9.0	95.0	95.0	95.0
10.0	95.0	95.0	95.0
11.0	95.0	95.0	95.0
12.0	95.0	95.0	95.0
13.0	95.0	95.0	95.0
14.0	95.0	95.0	95.0
15.0	95.0	95.0	95.0
CSVR	0.69	0.59	0.79
(Panel)			

Source: Expert Panel Meeting, New Orleans District USACE, March 14, 1996.

Table 4

IPET Tasks 9 - 10

Saltwater Depth-Damage Relationships for Non-Residential Structures, Percent Damage,

Percent Damaged			
Flood Depth (ft)	**Metal Frame**	**Masonry Bearing**	**Wood or Steel Frame**
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	1.7	0.0	3.5
0.5	13.2	13.1	36.5
1.0	13.7	13.5	36.8
1.5	15.2	14.3	36.8
2.0	17.2	15.0	41.1
3.0	19.7	21.9	41.1
4.0	19.7	22.3	48.5
5.0	20.1	24.0	48.5
6.0	20.1	24.0	48.5
7.0	20.1	30.7	49.5
8.0	27.6	30.7	49.5
9.0	33.9	30.7	65.0
10.0	41.6	30.7	65.0
11.0	41.6	30.7	72.5
12.0	41.6	30.7	75.0
13.0	41.6	45.0	77.8
14.0	44.5	45.7	77.8
15.0	44.5	46.7	78.8

Source: Expert Panel Meeting, New Orleans District USACE, March 27, 1996.

Table 5

IPET Tasks 9 - 10

Saltwater Depth-Damage Relationships for Non-Residential Contents, Percent Damage, Expert Panel (1-Week Damages)

	Percent Damaged							
Flood Depth (ft)	Eating & Recreation	Groceries & Gas Stations	Multi-Family Residences	Professional Businesses	Public & Semi-Public	Repairs & Home Use	Retail & Personal Svcs.	Warehouse & Contractor Svcs.
-1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.5	61.6	82.5	100.0	98.5	60.2	87.5	99.4	36.1
1.0	82.6	97.5	100.0	98.5	60.2	87.5	99.5	53.0
1.5	87.3	97.8	100.0	98.5	60.2	87.5	99.7	61.5
2.0	88.4	99.1	100.0	98.5	60.2	87.5	99.8	69.9
3.0	93.3	99.4	100.0	100.0	60.2	98.9	99.9	79.9
4.0	93.5	99.7	100.0	100.0	60.2	100.0	100.0	96.3
5.0	93.5	99.7	100.0	100.0	60.2	100.0	100.0	97.0
6.0	93.5	99.7	100.0	100.0	60.2	100.0	100.0	97.0
7.0	93.5	99.7	100.0	100.0	60.2	100.0	100.0	97.0
8.0	99.3	100.0	100.0	100.0	60.2	100.0	100.0	97.0
9.0	99.3	100.0	100.0	100.0	60.2	100.0	100.0	97.0
10.0	99.3	100.0	100.0	100.0	100.0	100.0	100.0	97.0
11.0	99.3	100.0	100.0	100.0	100.0	100.0	100.0	97.0
12.0	99.3	100.0	100.0	100.0	100.0	100.0	100.0	97.0
13.0	99.3	100.0	100.0	100.0	100.0	100.0	100.0	97.0
14.0	99.3	100.0	100.0	100.0	100.0	100.0	100.0	97.0
15.0	99.3	100.0	100.0	100.0	100.0	100.0	100.0	97.0
CSVR (Panel)	1.14	1.27	0.37	0.43	1.14	2.06	1.42	1.68

Source: Expert Panel Meeting, New Orleans District USACE, April 1, 1996.

Table 6

IPET Tasks 9 - 10

Depth-Damage Relationships for Vehicles

Flood Depth (ft) Over Ground	Percent Damaged Automobiles (Avg. Value $11,918)
0.5	2.3
1.0	22.8
1.5	54.2
2.0	95.8
3.0	100.0

Source: G.E.C., Inc., Commercial Operator Interviews, January, 1996.

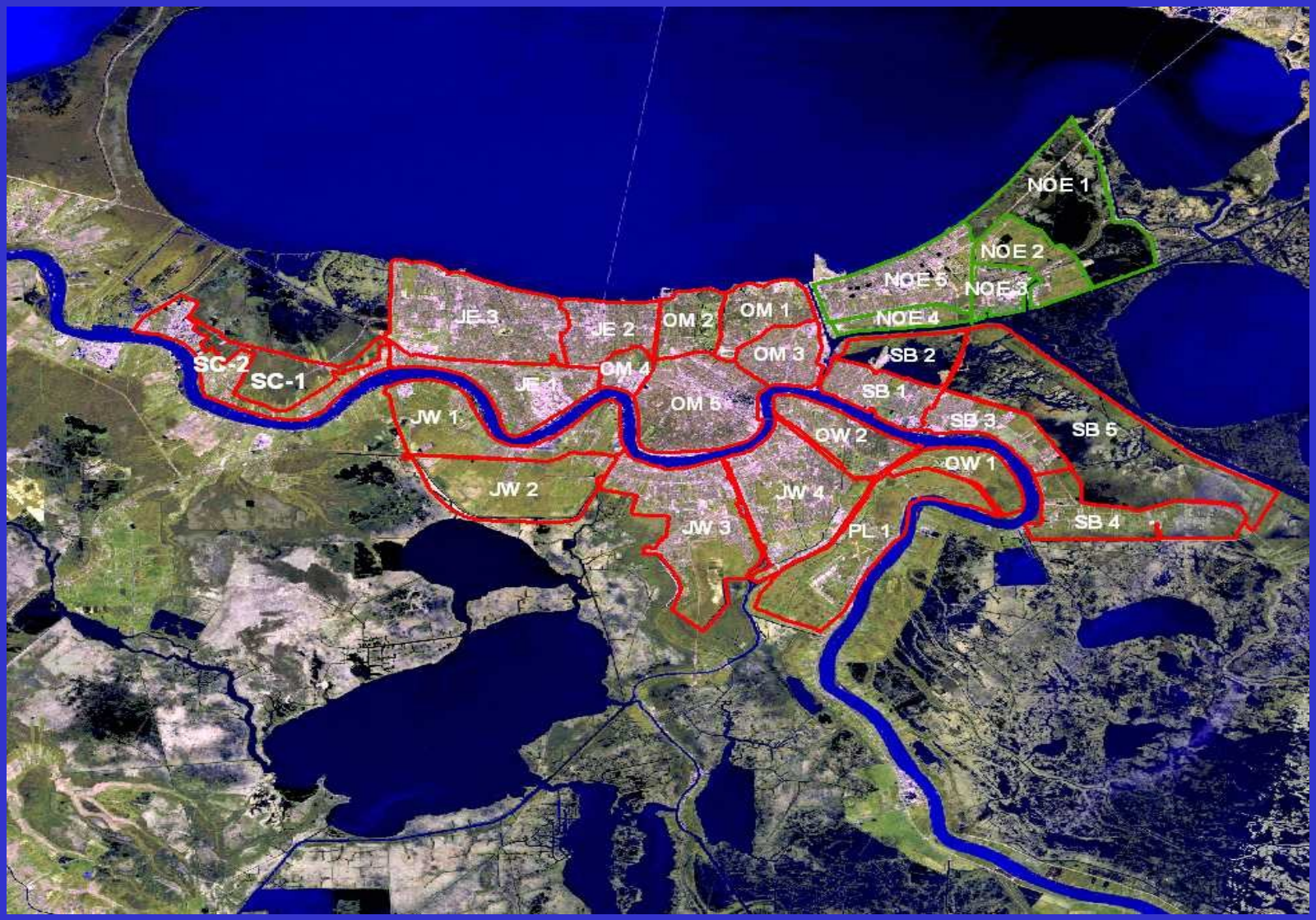
Inputs to Custom GIS Application

- Elevation Data
- Valuation of Structures, Contents, and Vehicles
- Depth-Damage Relationships
- Risk and Uncertainty Applied to Key Variables

Output of Custom GIS Application

- Water Elevation or Stage-Damage Relationship for Each Census Block
- Calculation of Flood Damages for Eight Damage Categories
  - Single-Family Residential
  - Multi-Family Residential
  - Mobile Homes
  - Commercial
  - Industrial
  - Public
  - Agricultural
  - Vehicles
- Aggregation of Flood Damages by Polders (Basins)

Map of Polders for the 5-Parish Area



PRELIMINARY AND SUBJECT TO REVISION
Direct Flood Damage in millions of 2005 dollars

WaterElevation	PolderName	5%	Mean	95%
-4	IJE1	0	0	0
-3	IJE1	0	0	1
-2	IJE1	0	0	7
-1	IJE1	0	1	38
0	IJE1	0	7	166
1	IJE1	1	36	319
2	IJE1	6	146	797
3	IJE1	35	289	1.086
4	IJE1	153	626	1.487
5	IJE1	299	853	1.881
6	IJE1	742	1.193	2.356
7	IJE1	1.022	1.507	2.609
8	IJE1	1.406	1.883	2.987
9	IJE1	1.788	2.095	3.322
10	IJE1	2.249	2.368	3.660
11	IJE1	2.497	2.642	3.910
12	IJE1	2.863	2.918	4.058
13	IJE1	3.190	3.137	4.138
14	IJE1	3.521	3.269	4.236
15	IJE1	3.767	3.340	4.288
16	IJE1	3.909	3.418	4.333
17	IJE1	3.987	3.460	4.381
18	IJE1	4.080	3.496	4.428
19	IJE1	4.130	3.533	4.463
20	IJE1	4.173	3.571	4.494
21	IJE1	4.219	3.600	4.508
22	IJE1	4.264	3.622	4.520
23	IJE1	4.298	3.631	4.527
24	IJE1	4.327	3.638	4.532
25	IJE1	4.341	3.643	4.533
26	IJE1	4.353	3.646	4.533
27	IJE1	4.360	3.646	4.533
28	IJE1	4.364	3.646	4.533
29	IJE1	4.365	3.646	4.533
30	IJE1	4.366	3.646	4.533
31	IJE1	4.366	3.646	4.533
32	IJE1	4.366	3.646	4.533
33	IJE1	4.366	3.646	4.533
34	IJE1	4.366	3.646	4.533

Calculation of Total Damages

- Average stage provided for each Polder associated with Hurricane Katrina and other storm scenarios

- Damages for each Polder were used to determine total damages associated with Hurricane Katrina and other storm scenarios

Internet Websites

Depth-damage Reports

http://www.mvn.usace.army.mil/pd/ESAB.htm

Interagency Performance Evaluation Team Report

https://ipet.wes.army.mil/